The GeoGLO Project:
Enhanced Access to Iowa's General Land Office Survey Plats

HRDP Grant 07-046

by

Joe Alan Artz and Melanie A. Riley

Joe Alan Artz
Director, Geospatial Program
Principal Investigator

Research Papers
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South Dakota:	South Dakota State Historical Society, Pierre
	South Dakota Archaeological Research Center, Rapid City
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	Midwest Archeological Center, National Park Service, Lincoln
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Figures

Township plats of the 1832–1859 General Land Office Survey of Iowa were scanned from microfilm and georeferenced to section corners depicted on 1:24,000 topographic quadrangles. Cultural features were digitized as points. A seamless mosaic of plats is published on two Internet Map Servers, with two other Web sites serving downloadable county mosaics and images of individual plats.

Introduction

General Land Office (GLO) survey plats for the State of Iowa are a record of the cultural and natural landscape of Iowa as it existed in the initial stages of its transformation by Euroamerican settlement. The plats show the locations of Native American villages and fields, as well as the first farmsteads, town sites, and fields established by Euroamericans. They also depict networks of newly-established and some probably ancient trails, and the distribution of rivers, woods, prairies, wetlands, and springs (Figure 1).

The plats record the 1832–1859 gridding of the land into parcels—the basis for its subdivision and sale to the immigrants. Present day historians, archaeologists, and environmental scientists find them a unique and significant source of scientific data on human settlement, plant communities and stream courses as they existed just prior to the wholesale transformation of the landscape in the middle to late nineteenth century.

The GLO plats impart a strong feeling for the landscape. To view the maps is to sense the vastness of the landscape as it must have seemed to the surveyors as they systematically worked across it with chain and compass. Early publications (MacBride 1896; Newhall 1849) give a sense of the state's natural richness and verdure, but the GLOs also convey the openness and immensity of the ungridded landscape.

Prior to this project, the GLO maps were most easily accessible on microfilm. Microfilms are available for viewing at the State Historical Society of Iowa's libraries in Des Moines and Iowa City, and at the University of Iowa Office of the State Archaeologist in Iowa City. Microfilm can also be obtained from the National Archives in Washington, D.C. Maps in paper format can be viewed at the State Historical Society Library in Des Moines. Given the dispersed locations housing the maps, they were relatively inaccessible to many if not most potential users.

The Geospatial Program at the University of Iowa Office of the State Archaeologist (OSA) envisioned scanning and georeferencing the GLO plats so that they could be made available on line and also used by advanced digital mapping tools such as Geographic Information Systems (GIS). Grant funding was obtained from the Historical Resources Development Program (HRDP) of the State Historical Society of Iowa.

Project Partners and Roles

The Office of the State Archaeologist (OSA) partnered in this project with the University of Iowa Libraries (UI Libraries), the Department of Natural Resources Iowa Geological Survey (IGS), and the GIS Facility at Iowa State University (GISU). Partner roles were as follows:

- The UI libraries purchased new microfilm from the State Archives, contracted with a private-sector vendor (Heritage Microfilms) for digital scanning of the film, and processed the images for publication as individual maps in the Iowa Maps Digital Collection, which is part of the UI libraries' Iowa Digital Library.
- OSA performed image cleaning, image clipping, and georeferencing of the individual scanned plats.

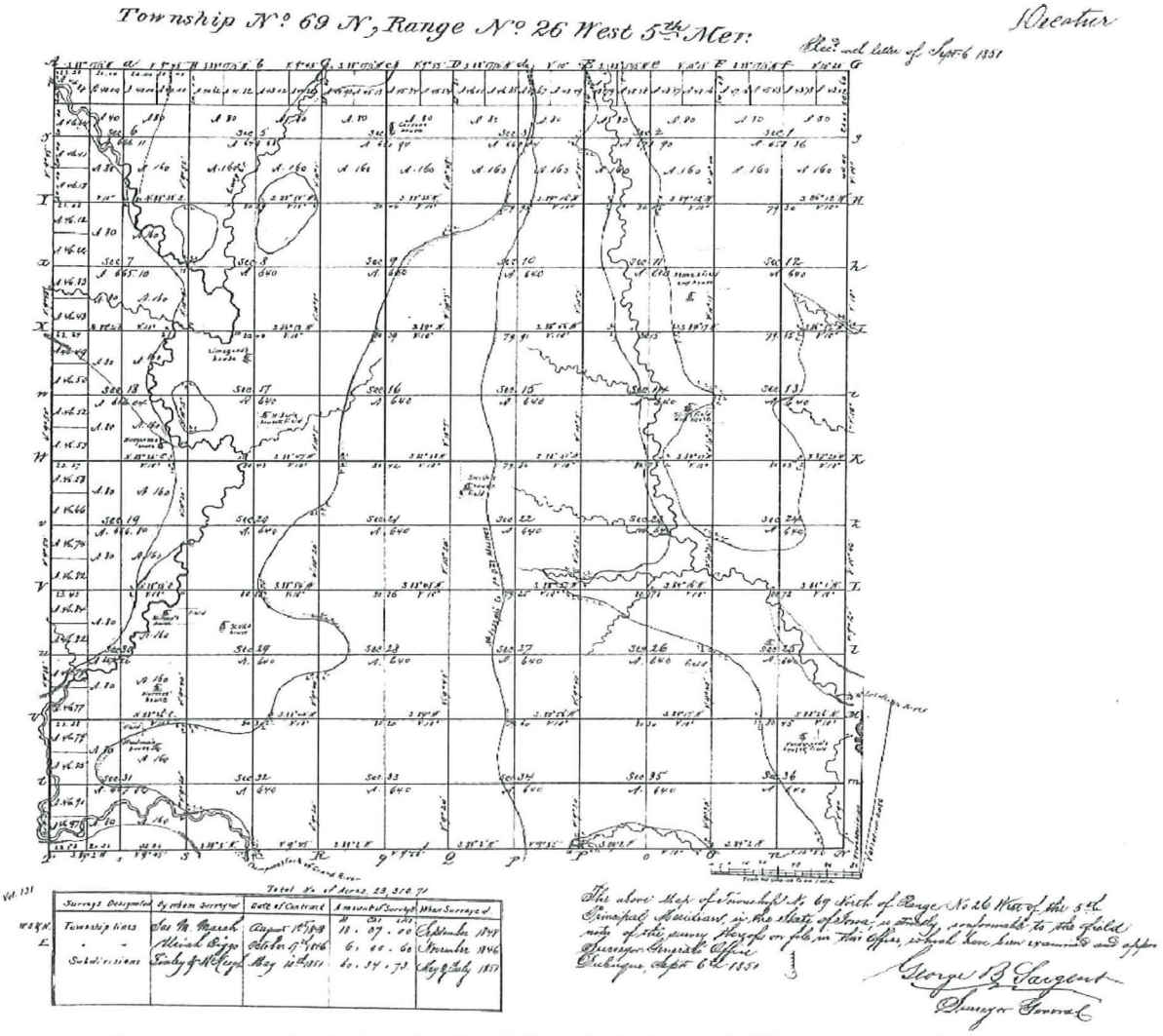


Figure 1. Example of a GLO plat, for Township 69N, Range 26W, in Decatur County, Iowa. Near center is a field and house beside a road or trail which crosses the township from north to south. Lines that parallel the meandering streams indicate the extent of the gallery forest.

- The Iowa Geological Survey (IGS) joined the plats into a seamless, statewide mosaic, and added them to the DNRs Natural Resources GIS (NRGIS) library.
- The GIS Support and Research Facility at Iowa State University (GISU) processed the joined images for serving on its Internet Map Servers (IMSs) of Iowa geospatial data.

Historic Background

The primary purpose of this section is to identify the lineage of the GLO plat microfilms used as source data for the GeoGLOs. First, however, a brief review of the history of the GLO surveys in Iowa is presented. An exhaustive treatment of this subject is available at (http://www.glo.gis.iastate.edu). This website, on-line since 2003, is the work of Paul Anderson and his students at the Iowa State University Department of Landscape Architecture. It includes an extensive bibliography for learning more about how, when, and why the GLO surveys were conducted.

THE PUBLIC LAND SURVEY SYSTEM (PLSS)

The General Land Office was a predecessor of today's Bureau of Land Management. The GLO was responsible for the survey of millions of square miles of public lands acquired by the United States as it expanded westward. Thomas Jefferson conceived the parceling of the public domain into a regular grid of 6-x-6 mi townships, each subdivided into 36 1-x-1 mi sections. A 640-acre section could be further divided into four aliquots of 160 acres (quarter sections), which could be divided into 40 acre quarter-quarter sections, 10 acre quarter-quarter-quarter sections, and so forth (http://nationalatlas.gov/articles/boundaries/a_plss.html).

The north-to-south "columns" and east-to-west "rows" of the public land survey system (PLSS) grid are identified by township and range numbers, respectively. Townships and ranges are numbered with respect to meridians of longitude and baselines of latitude. In Iowa, townships are numbered, south to north, from 68 to 100. Iowa's ranges are numbered with reference to the 5th principle meridian, which passes through the eastern part of the state. Ranges 1E to 7E are numbered in order to the east of, and Ranges 1W to 28W to the west of this meridian.

THE GLO SURVEYS OF IOWA

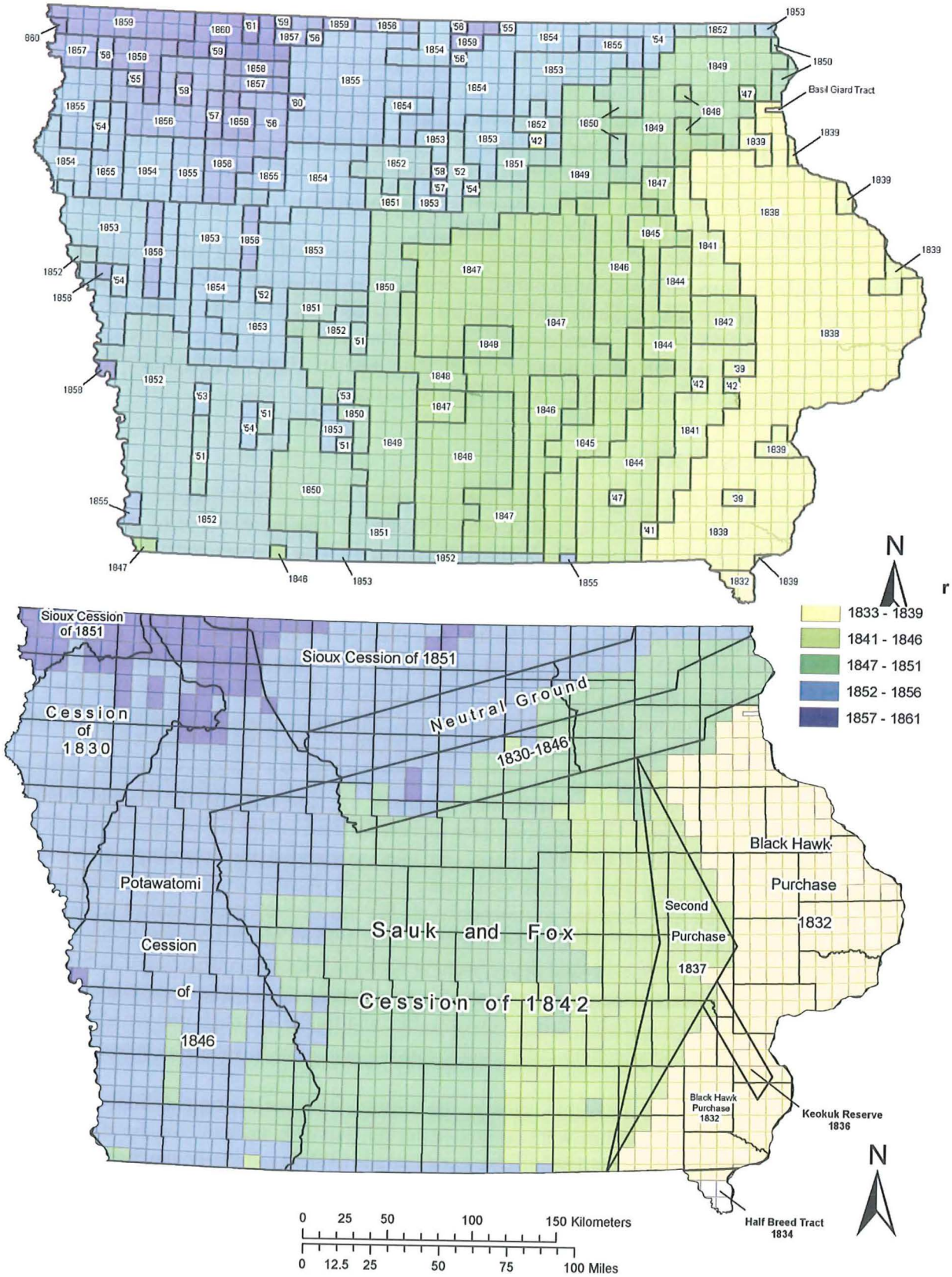
The GLO survey of Iowa began in 1836 and was completed in 1859 (Figure 2). The surveys followed close on the heels of Indian land cessions (Figure 3). The initial phase of land surveys, in particular, coincides closely with the Black Hawk Purchase of 1832. Survey certification lagged the cessions, however, by five years or more, perhaps explaining the large numbers of cabins, fields, and even towns that the GLO surveyors documented.

The surveys covered all of Iowa except for the so-called Half Breed Tract in Lee County, Iowa, which was surveyed in 1832–33 under contract to the Superintendent of Indian Affairs (Kelsay and Pernell 1971:17; Lokken 1942:13–16). Another exception was the Giard Tract (Figure 4), a 7-x-1.5 mi area in Clayton County that had left the public domain in 1816, when an act of Congress validated the late 18th century claim to the land by a Euroamerican trader, Basil Giard (Sage 1974:35).

Lokken (1942:13–64) discusses the year-by-year progress of the surveys in detail, including accounts from surveyor's notes and memoirs that document the hard and often dangerous conditions under which the parties worked. Using rudimentary surveyor's transits, compasses, and measuring chains, the surveys established township lines and then subdivided the townships into sections. Township and section corners were marked with posts, mounds of earth, or rock piles. Distances and bearings were measured and recorded in notebooks by the head of the party, known as the deputy surveyor. Deputy surveyors also recorded the distance along a given traverse at which they crossed a stream, or encountered a change in land cover, usually noted as vegetation types such as "timber" or "prairie" or "marsh." Meandering streams were often mapped in detail. The deputy surveyors also noted cultural features such as fields, farms, towns, mills, and trails. Although not yet officially open to settlement, over 10,000 people, both Indian and Euroamerican, lived in what was to become Iowa in 1836 (Lokken 1942:16).

Upon completion of each township survey, the deputy surveyor's original field notes and a topographic sketch of the township were submitted to the Surveyor General for the district within which the survey was made (Dodds 1943; Kelsey and Pernall 1971:21). Initially, the Surveyor General for the Wisconsin Territory, of which Iowa was a part, was located in Cincinnati, Ohio. In 1838, a Surveyor General's office was established in Dubuque (Lokken 1942) and most of Iowa's GLO surveys appear to have been submitted to this office.

If acceptable, the deputy surveyor's notes and map were used to draft the final township plat in triplicate. The original and each copy were signed and dated by the Surveyor General to indicate certification (Figure 1). The original plat remained with the Surveyor General in Dubuque; one copy



Figures 1-2: Time series maps, Iowa PLSS. Top: Survey General certification. Bottom. Certification relative to Indian land cessions (Royce 1899; reprinted 1971).

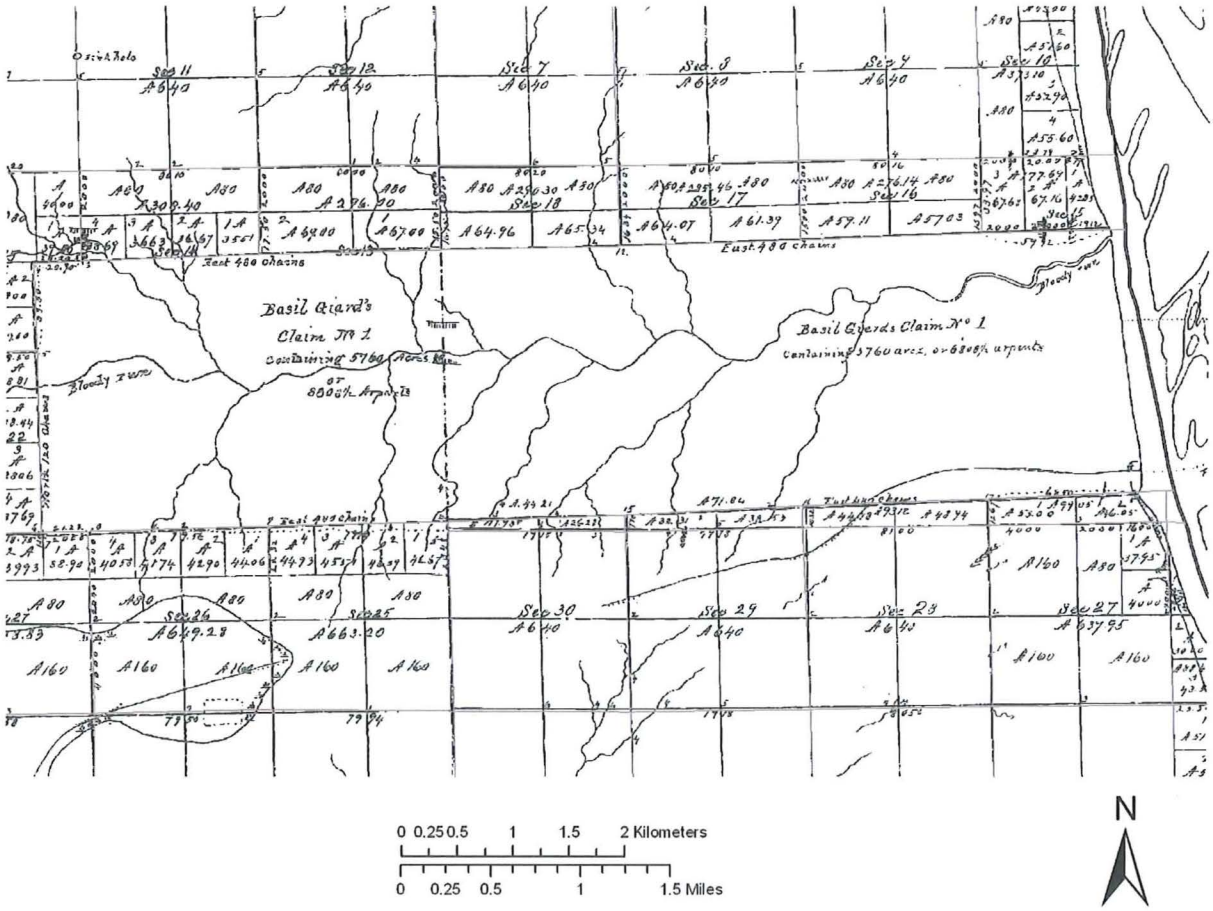


Figure 3. The Basil Giard tract, in southeast Clayton County, was privately owned at the time of the 1838 GLO survey, and therefore was not subdivided. Digital PLSS data sets identify this tract as "T00N, R00W."

was sent to General Land Office headquarters in Washington, D.C., and the third was sent to a local land office for use in registering entry claims onto the land as it passed from the public domain to private hands (Kelsay and Pernall 1971). Ten such offices were eventually opened across the state, as settlement spread westward (Sage 1974:69).

SURVIVING RECORDS OF THE GLO SURVEYS

The three copies of the notes and plats made by Surveyor General's office took a different path into the archives where they now reside (Figure 5). The present discussion focuses on the plats, but the notes follow similar, if not identical, trajectories.

The original notes and plats, retained by the Surveyor General, were transferred to Iowa's Secretary of State in 1868, the year the Dubuque office closed. The "headquarters copies," sent to Washington, D.C., remained with the GLO and its successor, the Bureau of Land Management, until they were turned over to the National Archives in 1959. The third set of plats, sent to local land offices, was also eventually sent to GLO headquarters and turned over to the National Archives in 1941 (Kelsay and Pernall 1971:22).

The original, Surveyor General's copies, held by the Office of the Secretary of State, were eventually transferred to the Iowa State Archives. The maps themselves are currently housed in the

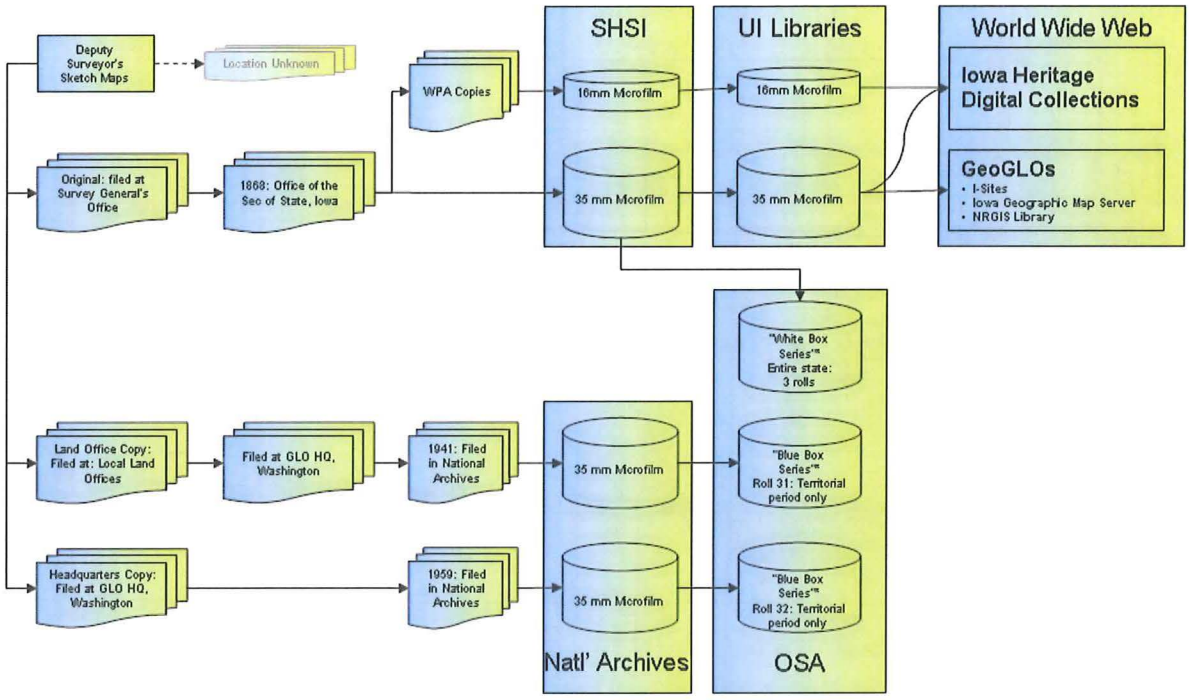


Figure 5. Flowchart tracing the production and archiving of Iowa's GLO plats

State Library at the State Historical Society of Iowa in Des Moines. A 35 mm microfilm, in 3 rolls, was sent to General Land Office headquarters in Washington, D.C., and the third was sent to a local land office for use in registering entry claims onto the land as it passed from the public domain to private hands (Kelsay and Pernall 1971). Ten such offices were eventually opened across the state, as settlement spread westward (Sage 1974:69).

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The original, Surveyor General's copies, held by the Office of the Secretary of State, were eventually transferred to the Iowa State Archives. The maps themselves are currently housed in the State Library at the State Historical Society of Iowa in Des Moines. A 35 mm microfilm, in 3 rolls, was made of these maps in 1979, and the original is at the SHSI library. Copies are housed at the State Historical Society of Iowa's library in Iowa City, and at the University of Iowa, Office of the State Archaeologist. OSA staff refer to this microfilm as the "White Box series" (Perry 1993) referring to the color of the boxes containing the film.

The headquarters and land office plats were microfilmed at the National Archives ca. 1971. Plats and notes dating from Iowa's Territorial period (1838–1846) were compiled into Rolls 31–40 of National Archives Microfilm Publication M325 (Kelsay and Pernell 1971:2). A copy of this 35-mm

microfilm is at the Office of the State Archaeologist and is known to the staff as the "Blue Box series" (Perry 1993).

In 1938, during the Great Depression, the Works Progress Administration sponsored a project to create typescript copies of the GLO survey notes for Iowa, and to draft copies of the township plats. The WPA copies of the notes and plats were bound into 301 paginated volumes, presently housed at the State Historical Society of Iowa in Des Moines (Perry 1993). In 1979, the WPA copies were microfilmed in 16 mm format by the State of Iowa. The copies are often inaccurate or overly generalized. They are immediately distinguishable from the GLO originals (Figure 1) by the typeset, fill-in-the-blank, township and range headings, and the typeset section numbers within the plat itself (Figure 6). The similarity of the typesetting from map to map indicates that a mass-produced form was probably used as a base map for the WPA copies. Copies of the 16 mm microfilm are housed at the State Historical Society of Iowa libraries in Des Moines and Iowa City. Anderson (1996) reports obtaining a copy of this microfilm from Professor Daryl Smith at the University of Northern Iowa.

For the present project, the University of Iowa libraries obtained new copies of both GLO microfilms housed at the State Library in Des Moines. One of these, the 35-mm film of the Surveyor General's original plats, includes the three rolls of township plats that were scanned and georeferenced by the present project. The second set obtained by the UI libraries is the 16 mm microfilm of the WPA copies.

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Previous Studies Using GLOs

Examples of previous, statewide compilation of information from the GLO plats include maps by the Iowa State Planning Board (1935) and the Trygg Land Office (1964, 1969). The 1935 map is entitled "Original Forest Cover," and according to the map legend is "based on data secured in the original land survey ... when all basic points, sectional lines, and township lines were established." The map is generalized, depicting only forest and prairie (Figure 7). The Iowa State Planning Board was a depression-era agency, funded by the WPA, that conducted surveys and compiled data of use in

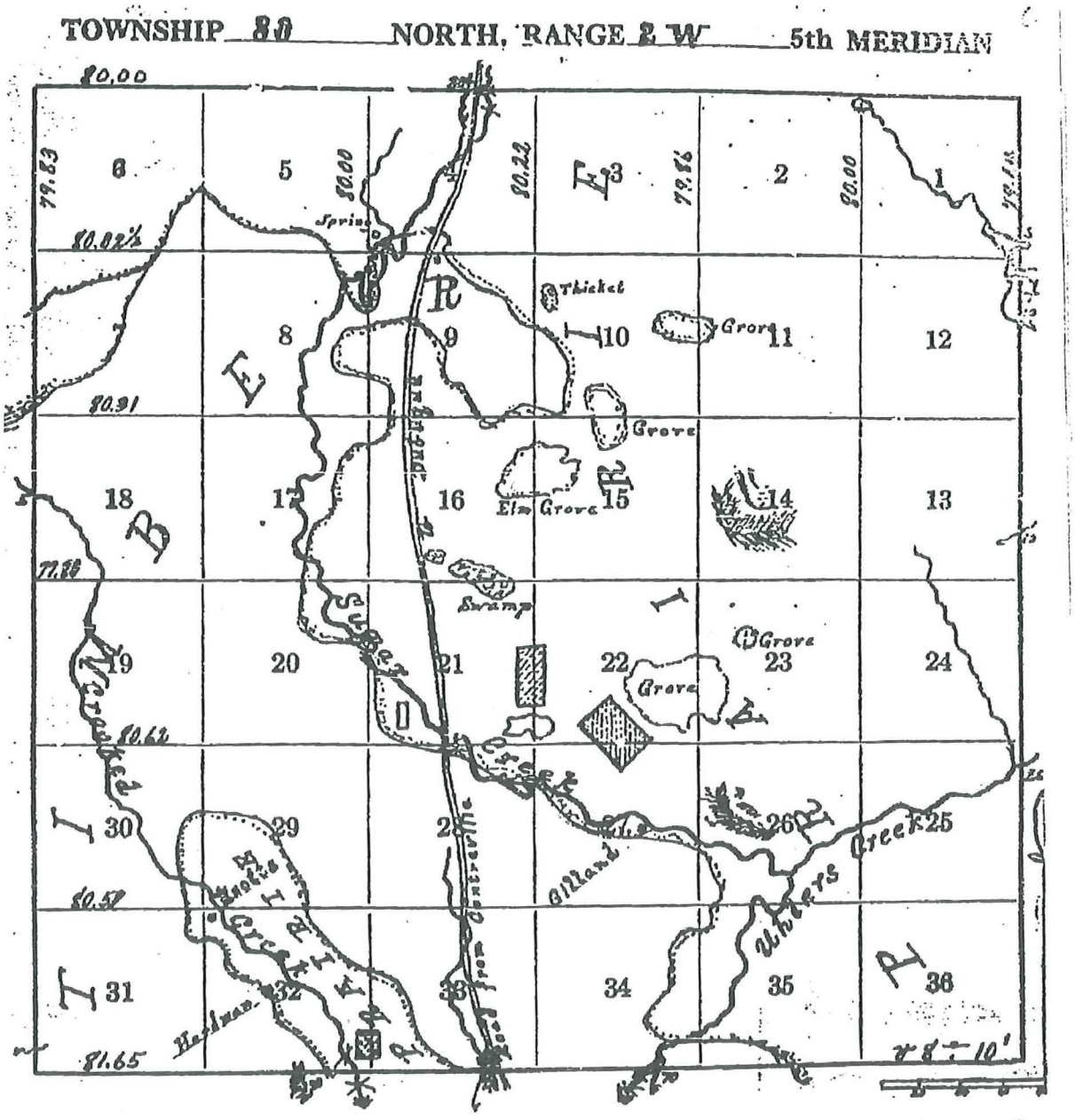

Figure 6. WPA copy of GLO plat, reproduced from Anderson (1996).

planning natural and human resource development. The relationship between the production of the Original Forest Cover map and the WPA transcription project described in the previous section is not known.

Reposed in the OSA archives are copies of composite maps created from GLO plats and survey notes by the Trygg Land Office, Ely, Minnesota (Trygg 1964). The maps reproduce vegetation boundaries, water features, and other features depicted on the GLO plats. Composites of all of Minnesota, large parts of Wisconsin and Michigan, and a section of northern Iowa roughly equivalent to the upper tier of counties are still available from the Trygg Land Office website. According to the website,

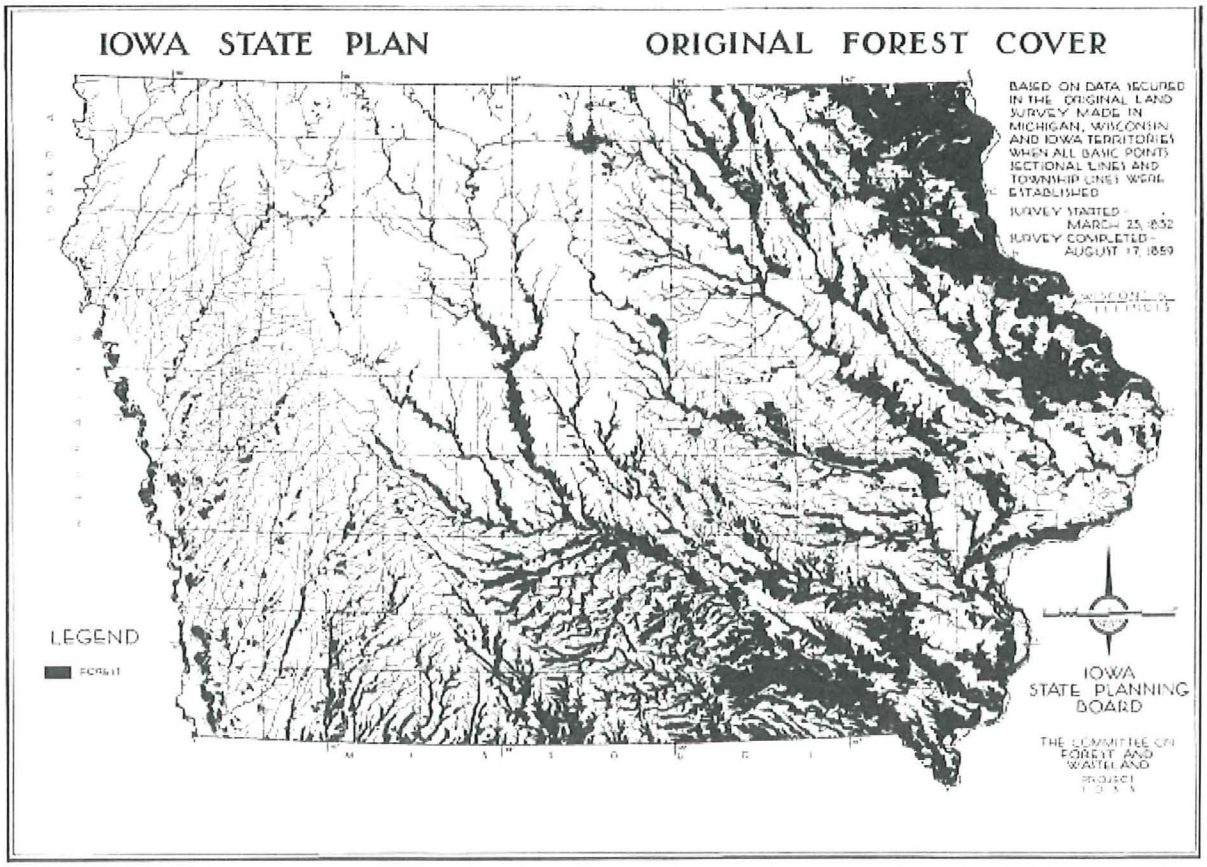

Figure 7. Map produced by the Iowa State Planning Board (1935) from GLO plats.

> "These maps were developed by J. William Trygg as a result of his employment as an appraiser for several Indian Tribes in their suits against the United States for adjustments of the amounts paid them for their lands when ceded to the government. The lands were valued as of the date of the cession and were not surveyed until after the cession, but before development was legally permitted" (http://www.trygglandoffice.com/about.html).

GLO survey plats have been used for varied research purposes in Iowa and elsewhere (http://www.glo.gis.iastate.edu). As early as the middle twentieth century, ecologists were using the plats and notes to reconstruct presettlement vegetation communities (Dick-Peddie 1955; Howell and Kucera 1956). When working in forested areas, the GLO surveyors were required to record "witness trees" closest to each section corner they established. The kind of tree, distance, and bearing were recorded in the notes. Thus, the notes provide information not only on forest composition but also, by using the distance measurements, estimates of the density of the forest cover (e.g., Miller 1995).

Archaeologists have used GLO-mapped vegetation boundaries as a proxy for the kinds of resource zones available to prehistoric hunter gatherers (King 1978; O'Brien et al. 1982; Wood 1976). Along with inferences of native vegetation from soils, GLO survey data have been used to create maps of what the prehistoric environment in the vicinity of sites would have been like (e.g., Collins 1990; Hirst 1990).

In the past two decades, several researchers have worked with GLO survey data using Geographic Information Systems (GIS) software. Anderson (1996) undertook a statewide project to digitize natural vegetation boundaries depicted on the GLO plats. The result was a mosaic of polygons, each Natural Resources GIS Library, and can be viewed with the Iowa Geographic Map Server.

Hedden et al. (2001) used GLO survey maps to identify the locations of the oldest known farmsteads in Johnson County, Iowa, and demonstrated that the most significant, best preserved, portions of the mid-nineteenth century archaeological record are likely to be found at farmsteads where historic maps and aerial photographs show no subsequent occupation.

Hedden et al. (2006) used GIS to create a database of GLO plats containing Native American and Euroamerican cultural features as an initial step in a study aimed at locating contact-period Native American sites in Iowa. Preliminary fieldwork suggests that mid 19th century archaeological sites exist at many of the locations marked as cultural features on the GLO plats.

Methods

PHASE 1: ACQUISITION

The UI Library acquired and accessioned digital images of the GLO plats and notes. The State Archives, at the State Historical Society of Iowa in Des Moines, has two sets of microfilms of the plats and notes. To ensure the highest image quality, the library purchased "fresh" film made directly from the archived, original films. One set is 35 mm microfilm of the original, hand-drafted plats and notes. The other set is of 16 mm microfilm of the WPA plat copies and typescript notes.

The UI Libraries arranged for Heritage Microfilm, Cedar Rapids, Iowa, to scan the purchased microfilm into bitmapped, Tagged Image Format (TIF) files. Copies of the TIF files were brought to OSA on an external hard drive. OSA staff examined each image and renamed the file to include the township and range designation that appears at the top of each plat. The images were then copied to OSAs server and the hard drive with the renamed images given back to the University libraries.

As of this writing, the 16 mm WPA microfilm has not been digitally scanned. The scanned plats are just beginning to be added to the UI libraries' Iowa Maps Digital Collection.

The scanned microfilm consists of 1,735 separate images. Most townships are represented by a single plat, but 67 are represented by two or more images. More than one image per township is considered an "addendum" to the original plat, and an "a" is added to the file name as an identifier. In those instances where multiple addenda for a single plat were found, a numeric identifier would be used in conjunction the "a" to label the additional plats. A few reasons exist for having multiple images for a single township. In some townships, larger islands positioned in rivers and lakes would merit separate surveys and therefore additional plats. Furthermore, in some cases, river meanders were recorded in greater detail on additional plats.

For nine townships, the plat was scanned twice, at different settings. The second scan of a plat was identified by appending a "2" to the file name, without discerning the quality of the scan. However, the best-quality image was then selected for georeferencing.

Plats of 28 townships are missing from the scanned image set (Table 1). Ten of the 1,640 township plats were missing from the microfilm obtained from the State Archives, from which the digital images were made (Figure 8). When these images will be provided is not certain. Also not included in our project were plats for the 1832 survey of the so-called Half-Breed Tract in Lee County. This tract was surveyed by the Bureau of Indian Affairs and not by the General Land Office.

Figure 8. Map of Iowa showing the locations of GLO plats not available for georeferencing.

Table 1. Townships Missing from SHSI Microfilm.

County	Township(s)	Range(s)
Dallas	T81N	R27W
Lee	T66N	R04–R07W
	T65N	R04–R06W
Lyon	T98N–T100N	R45W
Monona	T84N	R47W
	T85N	R46W–R47W
Plymouth	T90N–T93N	R45W
Sioux	T94N–T97N	R45W
	T96N	R43W
Woodbury	T86N–T89N	R45W
Union	T73N	R29W

PHASE 2: CLIPPING

The purpose of clipping is to allow the maps to be placed adjacent to one another like tiles in a mosaic, providing a statewide, "seamless" coverage. Clipping removed the margins, title, and legend from the image, retaining only the map information. During clipping, the images were also cleaned and saved to a format suitable for viewing, with white space represented as transparency, so that they can be used as an overlay on other images.

Clipping was done in Adobe Photoshop version 7.0.1, which was also used to clean marks on the map that resulted from dust, scratches and hair captured on the microfilm. ArcGIS, a product of ESRI, was also used for clean up (see below). For most townships, images were clipped along the township

lines. Map imagery that went outside of the township boundary, however, was preserved. This included items such as cabins, fields, feature labels, and Native American features. Map features that went outside the township lines were often not replicated on the adjacent township plat, and thus were represented only in the margins of a single plat. If a feature outside the township boundary overlapped with the same feature recorded inside its proper township, then the overlapping feature was cleaned up using ArcScan, an ArcGIS module that allows individual pixels to be erased. This method was used most often in the eastern third and the far southwest corner of Iowa where cultural features were the densest. The clipped images were then saved to a separate TIF file with "cl" appended to the file name, in order to preserve the original GLO maps, complete with margin notes.

PHASE 3: GEOREFERENCING

Georeferencing consists of registering selected section corners on each plat to corresponding corners on a United States Geological Survey (USGS) quadrangle base layer. This involved bringing each clipped township image into ArcGIS, laying it over a base layer of topographic maps, and georeferencing it by manually aligning the township and section corners of the GLO map to the township and section corners of the underlying USGS map.

The GLO maps were georeferenced in Zone 15 of the Universal Transverse Mercator (UTM) coordinate system using the North American datum of 1983. Georeferencing began in the eastern third of the state where the greatest concentration of cultural features occur on the maps. Specifically, the area includes all counties east of, and including, a north–south tier comprised of Mitchell, Chickasaw, Bremer, Black Hawk, Benton, Iowa, Mahaska, Monroe, and the eastern half of Wayne. The central Iowa counties of Polk, Dallas, and Warren were digitized, followed by the western Iowa counties of Fremont, Mills, Pottawattamie and Harrison (Figure 9).

For this initial group of counties, georeferencing was accomplished by setting pairs of control points at every section corner; one point at a GLO section corner, and the other at the corresponding section corner on the USGS quadrangle. A 3rd order polynomial transformation was then used to align the GLO image to the base map. Accuracy statistics indicate that, for most counties, 90 percent of the section corners on the georeferenced plats are ±50 ft (15.2 m) from the corresponding corner on the USGS quadrangle. A few counties, such as Delaware, have such skewed section lines that 3rd order polynomial transformation was not very effective.

This method was relatively slow because of the number of control points that needed to be set for a satisfactory transformation. After about one third of the counties were complete (Figure 9), a quicker, but still satisfactory method was developed. Control point pairs were set only on section corners located on the township boundaries (a total of 24 points: 4 at the township corners, and 5 section corners along each side). The GLO image was then aligned to the quadrangle using a spline transformation. Townships aligned using this method are located in south to north central and northwestern counties (Figure 9). Nine of those counties were completed by the Iowa Geological Survey, also using the spline transformation. Using this method, the match of GLO section corners to the topographic maps is ±50 ft (15.2 m) for 80 percent of the section corners sampled. However, for counties with skewed section boundaries, the number of GLO section corners that match the topographic map section corners is much higher than the 3rd polynomial transformation method.

In the course of georeferencing, OSA upgraded its ArcGIS software from version 9.0 to 9.2. A programming bug in the new version that affected georeferencing was immediately discovered. A successful workaround, requiring a few additional process steps, was developed. Details of the workaround are posted on the ESRI forum at ArcGIS Desktop — Raster display and management (http://forums.esri.com/Thread.asp?c=93&f=1740&t=209585) under the posting by Melanie Riley.

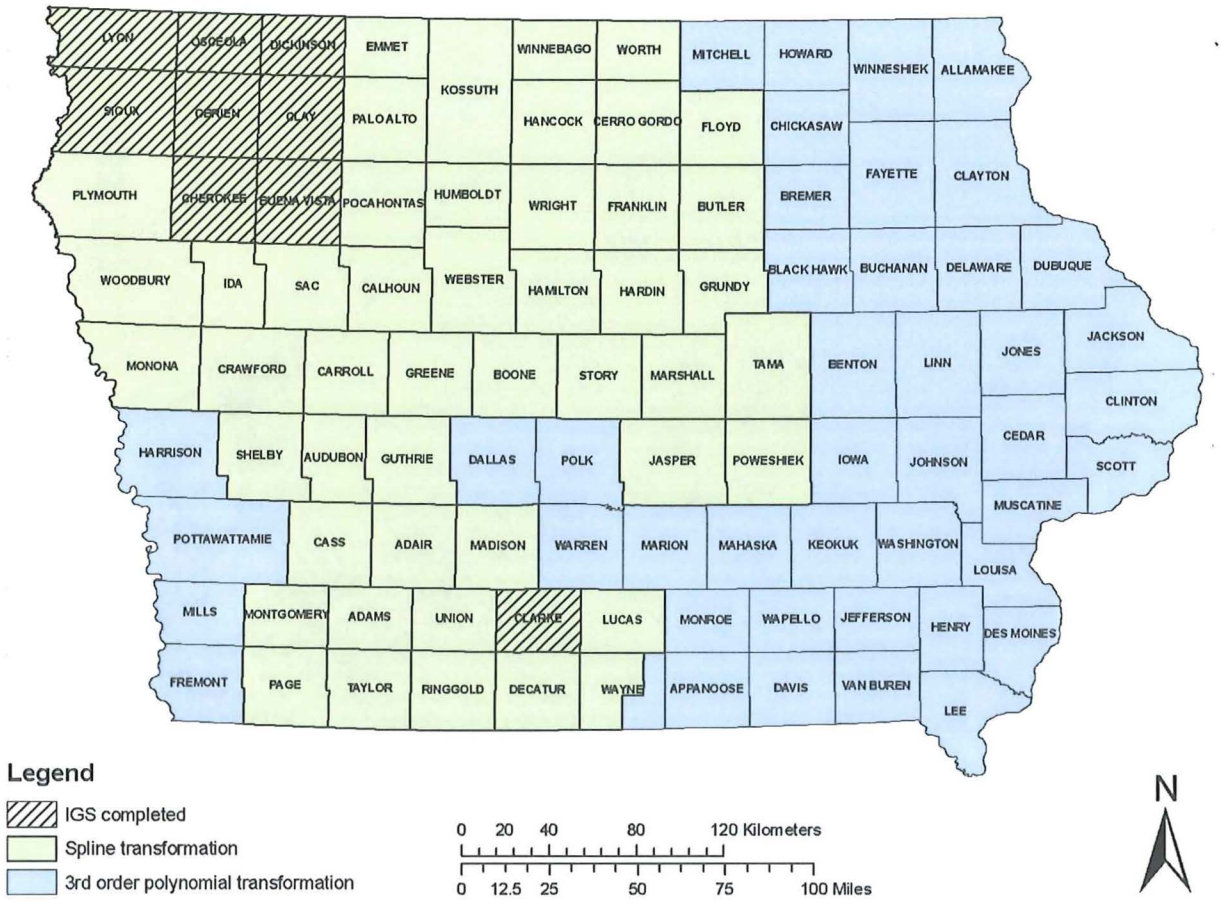

Figure 9. County map of Iowa showing method used to georeference GLO plats.

Cultural Features

Georeferencing provided an opportunity to examine each plat for cultural features. Locations of these features were captured in a GIS shapefile by placing a point at the center of the feature and, in an accompanying attribute table, entering a description of the point. This shapefile, which project staff named "Anthropoints" was outside the scope of the HRDP project, but data gathering could be done so quickly, it did not significantly affect progress. A disadvantage of using points, of course, is that the total extent of large features such as fields and towns is not represented. Trails, of which there are many on the plats, should have been represented as lines, but could not have been digitized in the available time. A total of 4,584 "anthropoints" were digitized from the maps (Figure 10, Table 2).

Soon after the geoGLOs went on-line, OSA received requests to also provide a layer showing the dates of the maps. Archaeologists wanting to know more about a farmstead or other cultural features depicted on the GLOs also needed to know the likely date at which the farmstead was occupied. John Hedden at OSA, in a previous project, had recorded the date that each township plat was certified by the Surveyor General. This data table was joined to the NRGIS Library's township shapefile, resulting in a dataset that can display the certification date in a GIS.

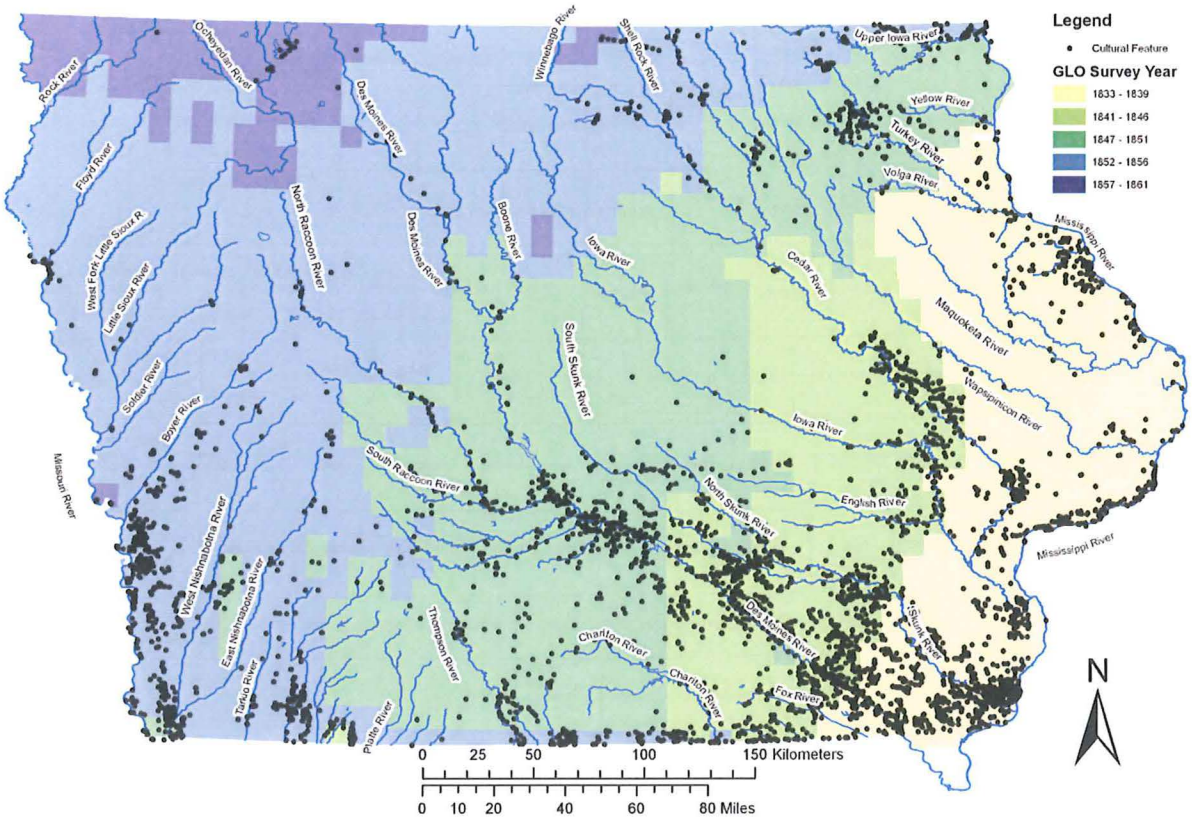

Figure 10. Map of Iowa showing the locations of cultural features plotted on the GLO plats.

Table 2. Kinds of Cultural Features Found on the GLO Plats in Iowa

Description	Total	Percent	Description	Total	Percent
Contact-Related			Euroamerican Transportation		
Agency	2		Ferry	10	
Battlefield	1		Road	270	
Fort	6		Trail	107	
Indian Council	2		Total	387	8.4%
Total	11	0.2%			
			Indian Grave	9	0.2%
Euroamerican Field	2267	49.5%	Indian Habitation		
			Village	16	
Euroamerican Grave or Cemetery	7	0.2%	Wigwams	6	
			Total	22	0.5%
Euroamerican Habitation					
Cabin	1650				
Town	100		Indian Trail	22	0.5%
Total	1750	38.2%			
			Indian Field	5	0.1%
Euroamerican Industry/Commerce					
Business	4		TOTAL	4584	
Mill	70				
Mining	30				
Total	104	2.3%			

PHASE 4: MOSAICKING

The process of creating a mosaic was done at the Iowa Geological Survey. The individual township maps were 1-bit datasets, in which 0 represents a white (background) pixel and 1 represents a black (ink, on the original plat) pixel. The maps were joined into a mosaic with ArcMap 9.2 into a statewide 2-bit dataset using a minimum function to give lines priority. The values were then remapped into a 2-bit dataset, shifting lines to value 2, with background still 1. Areas outside a narrow buffer around the state were clipped to value zero. The statewide mosaic is distributed as an ESRI GRID, a raster format that stores pixel values in a data table, rather than in the image itself, greatly reducing the file size. The statewide mosaic occupies only 650 MB, but contains all the information available on the TIFs, which occupy 1–2 MB per township plat.

The mosaic was uploaded to OSAs password-protected, I-SitesPro map server, the Iowa Geological Survey's NRGIS Library (http://www.igsb.uiowa.edu/nrgislibx/) and Iowa State University's Iowa Geographic Map Server (http://ortho.gis.iastate.edu/). Screenshots of the available Web interfaces are shown in Figures 11–14. I-SitesPro, a password-restricted resource available only to qualified professionals who obtain a license from OSA, displays the plats, anthropoints, and labels indicating the certification date. The anthropoints are labeled thematically. White areas on the plats are transparent, allowing them to be overlain on USGS 1:24,000 quads. In Figure 11, the map also displays modern roads. The interface allows panning and zooming of the map display.

The Iowa Geographic Map Server (Figure 12) started out as a Massachusetts Institute of Technology application that displayed black-and-white, orthorectified photos of Iowa. Although now maintained by Iowa State University, many still refer to it as "the orthoserver." This map server displays over 20 image layers, including USGS topographic maps and aerial photographs from a variety of sources. Anderson's (1996) GLO vegetation maps are also available on the orthoserver. Modern streams and roads can be overlain on the maps, but only one image layer can be viewed at time. The maps can be panned and zoomed. The image layers in the Iowa Geographic Map Server can also be added directly to ArcGIS as a Web Map Service (WMS). This allows users to overlay their own GIS data on the remotely-hosted images from the Iowa Geographic Map Server. The data can only be viewed, not downloaded or modified, when added as a WMS.

Images of the original, unclipped GLO plats are being made available on the Iowa Digital Library (Figure 13). All the marginal information is retained on these images. They are displayed individually, rather than mosaics, and overlaying is not possible. The images can be scrolled and magnified. An excellent feature of the Iowa Digital Library is the metadata provided along with each image. This website provides the best information on the historical background of the survey plats, including the survey party head, the date each stage of the survey (e.g., township lines; subdivision into sections) was completed, the name of the Surveyor General, and the date of plat certification.

The Natural Resources GIS Library allows downloading of the GLO mosaic one county at a time or for the whole state under the Land Description hyperlink (Figure 14). Metadata can also be obtained. To be used in a GIS, the world file must also be downloaded. The world file is a special text file that contains georeferencing information that allows the GIS program to locate the plats on the earth's surface.

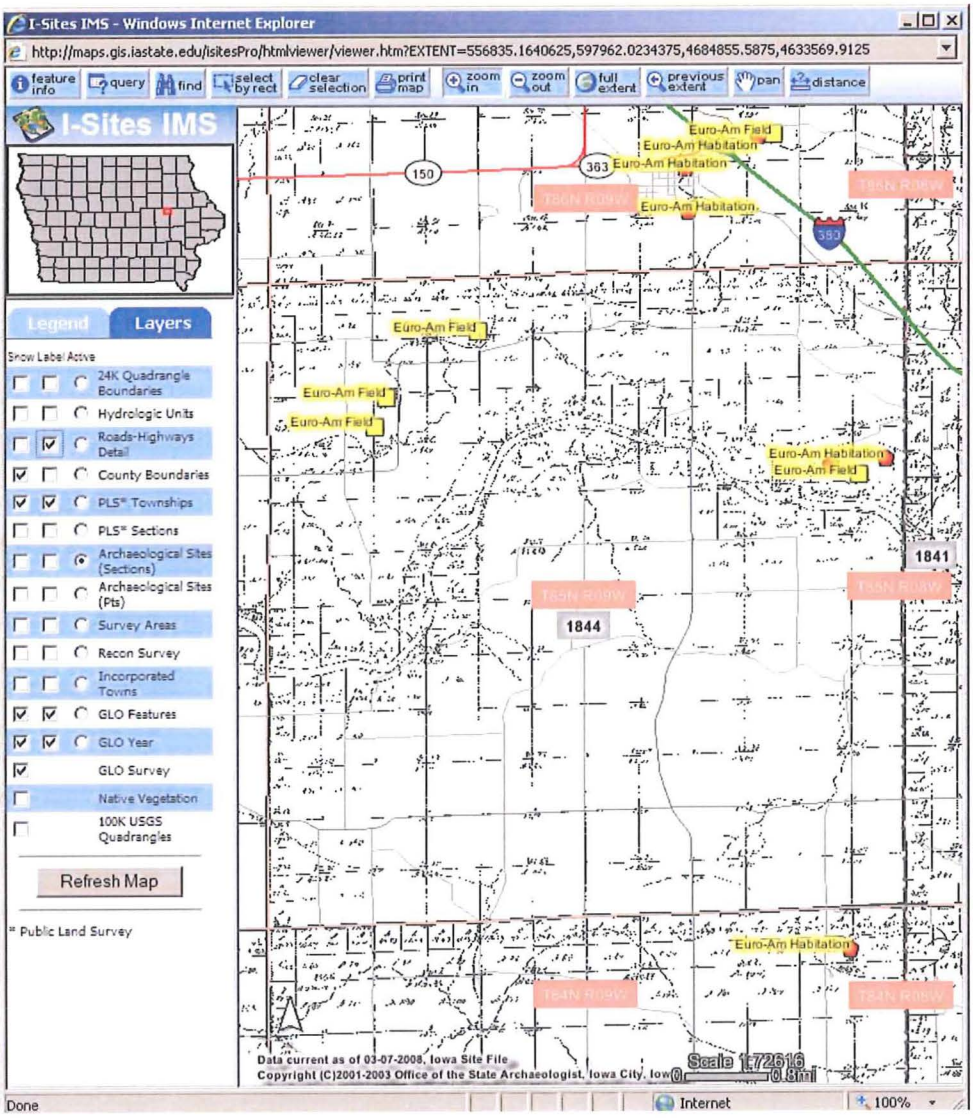

Figure 11. GLO plats and anthropoints as presented on I-SitesPro, a restricted access Web map server that is licensed for use by cultural resource professionals only.

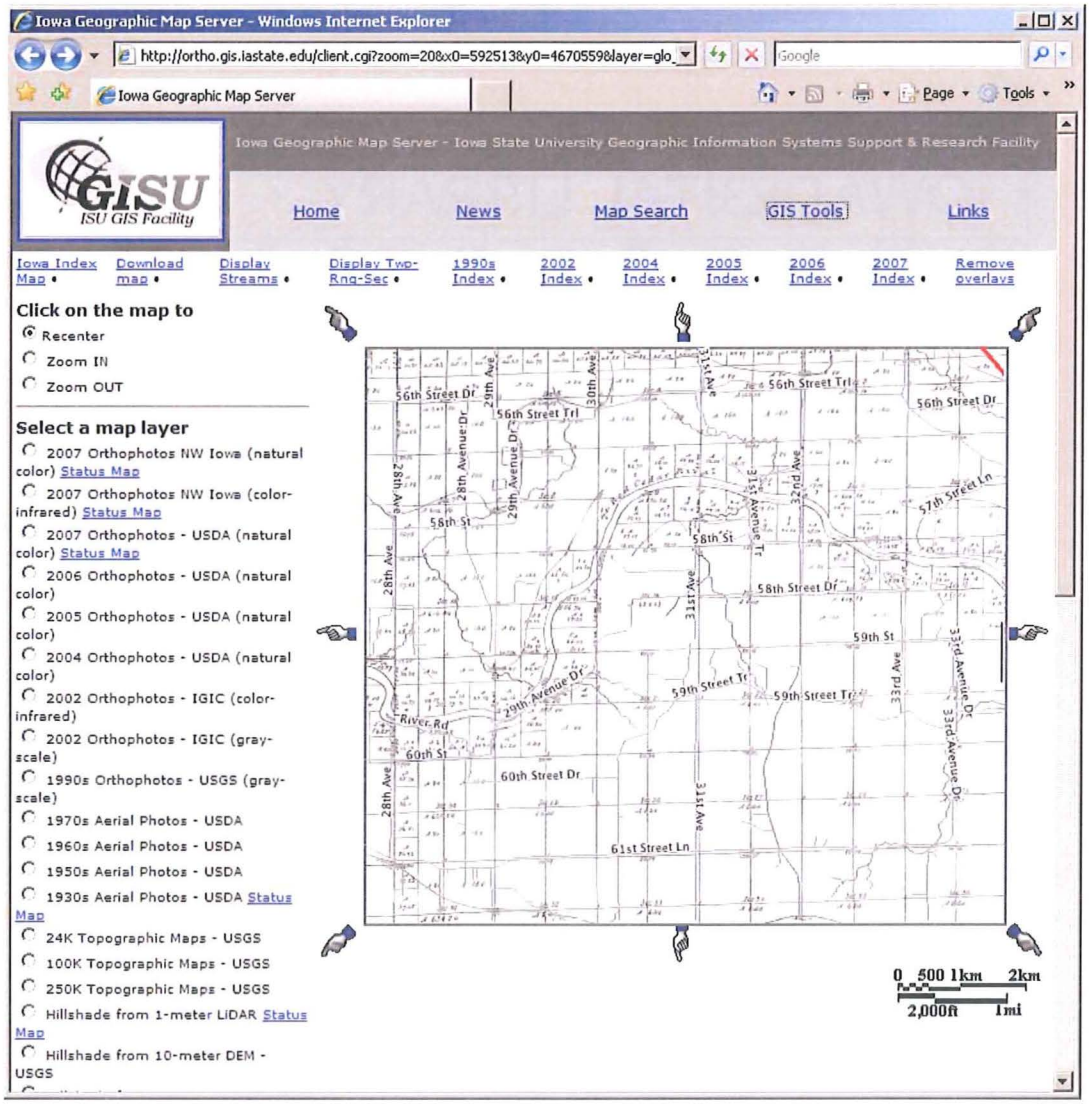

Figure 12. GLO plats as presented on the Iowa Geographic Map Server, a Web map server with unrestricted access.

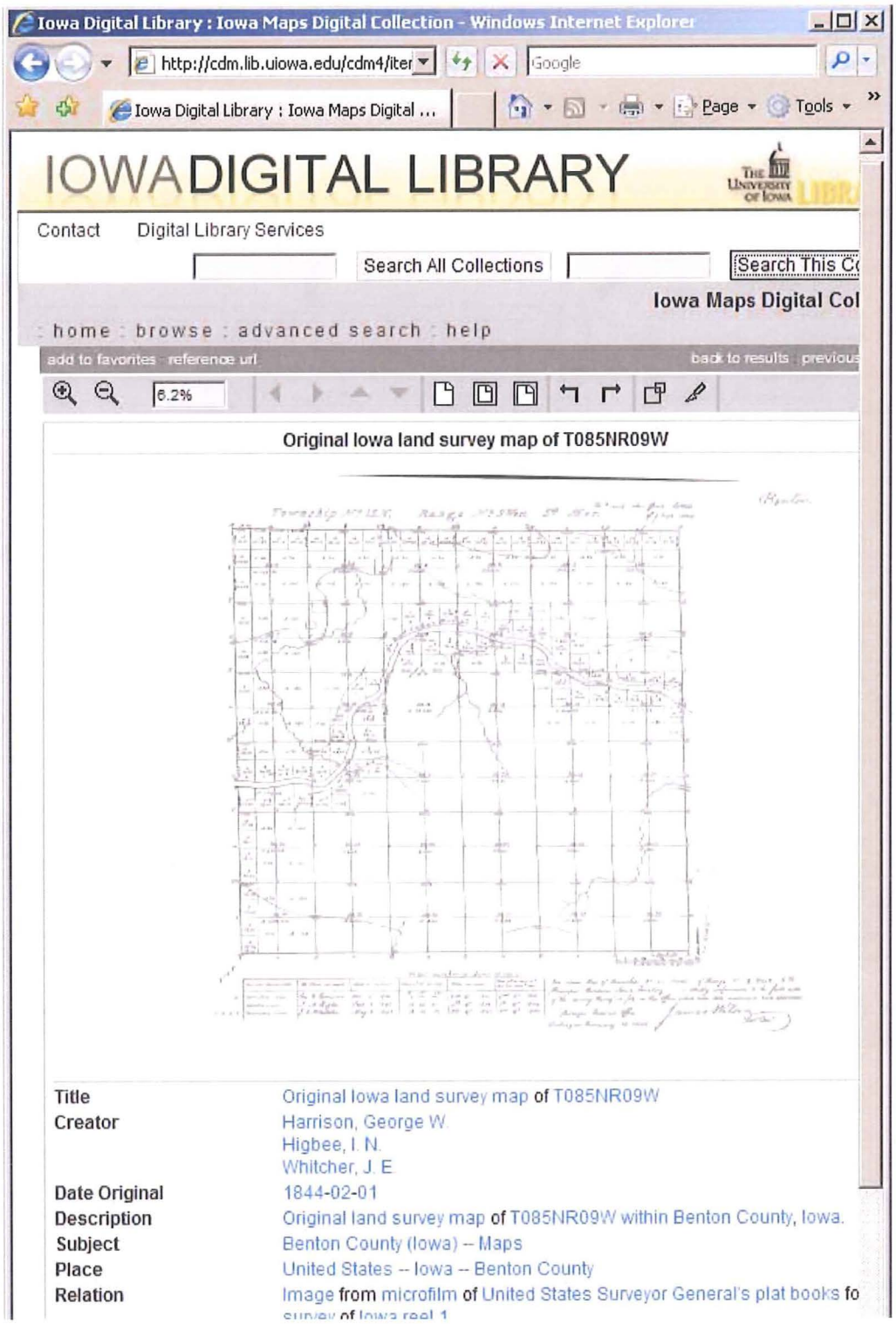

Figure 13. GLO plats as presented by the Iowa Digital Library, a Web map server with unrestricted access.

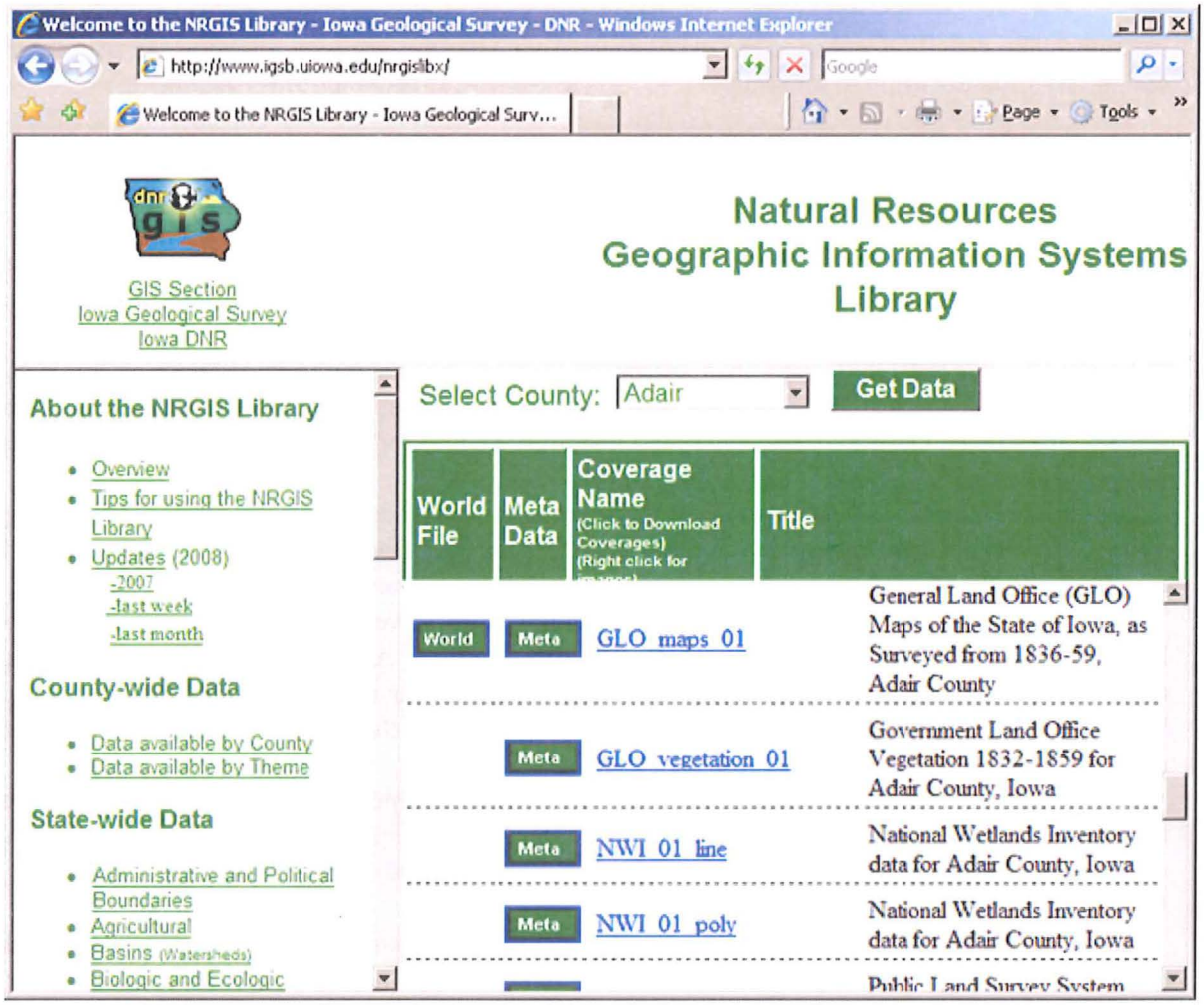

Figure 14. Links to metadata and downloadable GLO plats on the unrestricted access, Natural Resources GIS library web site.

PHASE 5: PROJECT DOCUMENTATION

The Federal Geographic Data Committee (FGDC) within the United States Department of Interior has developed standards for GIS metadata. Metadata are sometimes referred to as "data about data." They provide information about the purpose, content, size, spatial extent, format, and availability of a GIS data layer. FGDC-compliant metadata was created for the geoGLOs and anthropoints using metadata tools in ArcGIS 9.2. Metadata are available on line at http://www.igsb.uiowa.edu/nrgislibx.

Conclusions

The geoGLOs provide on-line access to a mosaic of the initial, General Land Office surveys of Iowa. Four advantages of this format can be identified. First, digital, on-line availability will reduce usage of, and therefore conserve, the paper and microfilm versions. Second, the geoGLOs are easier to use. Presently, searching the microfilmed GLOs for a specific locality requires knowing its township and range designation. In contrast, when viewed in a GIS or an Internet map server, users can locate their area of interest with reference to familiar features like towns, roads, tree lines, and farm fields visible in aerial photographs. The geoGLOs can then be turned on to view the initial land survey plat for that locality, with the additional functionality of being able to zoom in and out, or pan to other

locations. The geoGLOs enhance the experience of viewing the maps by allowing the user to cross seamlessly from township to township.

Third, the geoGLOs will assist city, county, state, and federal planners in considering the effects of development on historic cultural resources. Used in this capacity, the geoGLOs will hopefully streamline the land use planning and decision-making process by giving all involved in such decisions equal access to an important, primary source of historical data. The geoGLOs will be available to K-12 educators for use in teaching subjects such as history, biology, and geography. At the local level the geoGLOs will be available to anyone interested in the history of their land, families, and communities.

Fourth, having the GLO maps in a geospatial context facilitates the creation of vector data of historical, anthropological, and landscape features and aids in spatial analyses of phenomena such as settlement patterns. Derivative maps that will hopefully be developed from the GeoGLOs include the following examples.

A polyline shapefile should be created of the numerous trails denoted on the maps. GLO-mapped trails comprise the earliest statewide documentation of transportation networks in Iowa, and if digitized for GIS, would be a valuable resource for historians and archaeologists.

A polygon shapefile should be developed of features such as vegetation boundaries, river courses, lakes, marshes, and agricultural fields represented on the maps. Anderson (1993) created a polygon coverage of vegetation zones and fields. Recent technologies for converting raster images to vector lines, such as ESRIs ArcScan, have improved to the point that a more detailed and accurate representation of the GLO-mapped boundaries could be obtained.

Most cultural features recorded from the GLOs in the "Anthropoints" shapefile are not recorded in the Iowa Site File, which is a master inventory of archaeological sites in Iowa, maintained by OSA. A check of the Iowa Site File GIS revealed that 65 recorded, historic-period archaeological sites are located within 65 m of a GLO anthropoint (Figure 15).

Anthropoint sites not recorded in the Iowa Site File should be added to that file. The Iowa Site File is the preservation community's primary source of information for archaeological sites in the state. A check of the Iowa Site File is the first step in determining whether sites exist in areas posed for development. While the geoGLOs provide an additional check, the checking process would be facilitated and reinforced by assigning site numbers to GLO cultural features and including them in the Iowa Site File. The sites would be represented in the Iowa Site File GIS as an "inverted triangle," an icon that indicates the location of the site is known, but its horizontal extent has not been determined. Recording the sites would be an impetus to visit them to determine their integrity.

There are disadvantages to a seamless mosaic of the GLO maps. Clipping the maps to their boundaries removes all information that is contained in the collars. Soon after the geoGLOs were added to the Orthoserver, a professional civil surveyor e-mailed to stress the importance of the margin information.

> ...These maps are used by my profession daily, the data we are most interested in are the original dimensions on the township lines. In Iowa during the early surveys the original instructions upon closing on the West and North Township Lines was to set a closing corner and show the fall to the standard corner.... The closing distances between the junior and senior corners were placed on the maps at the edges. Also the stream meander data as well as the magnetic declination information are not present.

The present project compensates for this disadvantage by also serving the original, unclipped plat on a separate web server, the Iowa Digital Heritage Library (Figure 13).

A second disadvantage is the public release of information containing historic site locations. Artifacts such as glass containers and ceramic vessels from historic sites have monetary value, and sites where they are found are subject to indiscriminate digging. The on-line GLOs make it easier to

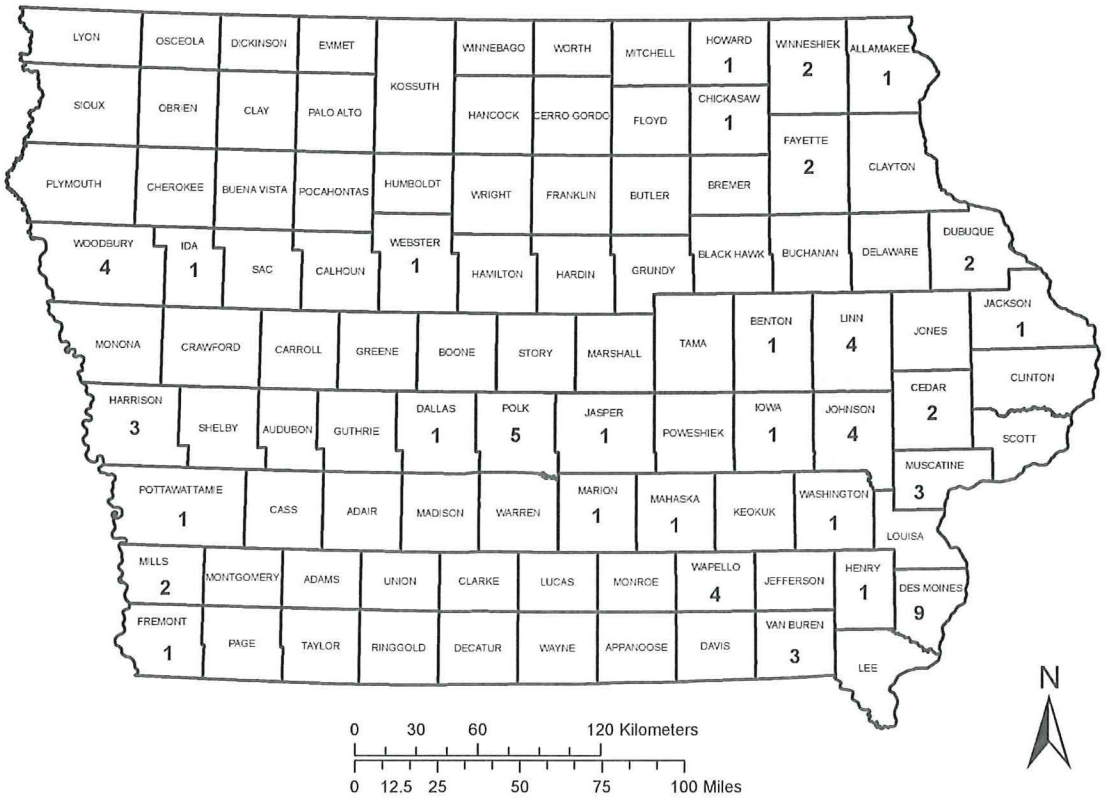

Figure 15. Sixty-five sites in the Iowa Site File are within 65 m of a GLO anthropoint. This map shows their distribution among counties.

learn the locations of such sites, but at the same time, the information is also available to landowners, educators, county conservation boards, as well as cultural resource professionals, with an interest in preservation. Ready access to information poses risks, but also poses opportunities for protection of, and education about, such sites at the local as well as state and federal levels. In the long run, improved access to the geoGLOs offers great opportunities for research in both human and natural history research. Citizens will be able to better visualize the land as it was before the plow, field, road, and town, and this will hopefully strengthen their desire to be its conscientious stewards.

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As lead author, I extend my thanks to Melanie Riley and John Hall who carried the load of this project, scrolling and clicking their way across millions of acres of nineteenth century Iowa. In many ways, their work was not dissimilar to that of the GLO surveyors, their purpose being to establish the points on the earth surface to which the maps would be tied. The high standards they set for themselves, and maintained throughout the project, are evident in the final product.

I also thank our project partners: the University of Iowa Libraries, especially Nancy Kraft; the Iowa Geological Survey, in particular Pete Kollasch, Sally Hakes, Casey Kohrt, and Jim Giglierano; and the GIS Facility at Iowa State, especially Pipat Reungsang. Their enthusiasm was appreciated, and their matching funds were nice, too. Melanie, John, and I are grateful to our colleagues at OSA for creating a friendly, but focused work environment. I'm particularly indebted to John Doershuk and Mike Perry, whose thorough editing of the draft report greatly improved the final. Finally, I acknowledge Paul Anderson, who led the way.

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